IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art Unit 1742

In re

Patent Application of

Toshihide Ito et al.

Application No. 09/671,084

Confirmation No. 6569

Filed: September 27, 2000

Examiner: Sikyin Ip

"Sn-Ag-Cu SOLDER AND SURFACE TREATMENT AND PARTS MOUNTING METHODS USING THE SAME"

I, Elizabeth M. Campbell Tressler, hereby certify that this correspondence is being deposited with the US Postal Service as first class mail in an envelope addressed to Mail Stop Appeal Brief-Patents, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date of my signature.

Elizabeth M. Campbell Tressler
Signature

5/2/2005
Date of Signature

APPEAL BRIEF

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to the Notice of Appeal filed in the above-identified application on February 1, 2005, and 37 C.F.R. § 41.37, applicant submits this Appeal Brief in triplicate. This Appeal Brief is filed with a one-month extension of time pursuant to 37 C.F.R. §41.37(e) and 37 C.F.R. §1.136, thereby extending the reply deadline to May 2, 2005.

A check in the amount of $620.00 is enclosed in payment of the fees required under 37 C.F.R. §41.20(b)(2) and under 37 C.F.R. §1.17(a). In the event applicant has overlooked any other charges or has made an overpayment in connection with this Appeal Brief, please charge or credit Deposit Account No. 50-1965.

I. REAL PARTIES IN INTEREST

The real parties in interest are NEC Toppan Circuit Solutions, 2-2-7, Yaesu, Cho-ku, Tokyo 104-0028, Japan, and Solder Coat Co., Ltd., 75-1, Chota, Narumi-cho, Midori-ku, Nagoya-shi, Aichi, Japan.

II. RELATED APPEALS AND INTERFERENCES

A Notice of Appeal was filed on March 1, 2005 in connection with U.S. Patent Application No. 10/127,927, filed on April 23, 2002, which is a divisional of the present application. An Appeal Brief has not been filed in connection with U.S. Patent Application No. 10/127,927 as of yet. There are no related interferences.

III. STATUS OF CLAIMS

This is an appeal from the rejection set forth in the Office Action dated November 2, 2004, rejecting all claims pending in the case (claim 1-3, 5, 6, and 8). Claims 4, 7 and 9-24 were previously cancelled. The pending claims have been rejected numerous times in this case and, therefore, have been "twice rejected" pursuant to 37 C.F.R. § 1.191. The claims on appeal are reproduced in clean form in Section VIII, below.

IV. STATUS OF AMENDMENTS

Pending claims 1-3, 5, 6 and 8 were last amended in applicant's Preliminary Amendment dated July 26, 2004, and are reflected in the claims reproduced in clean form in Section VIII, below.

V. SUMMARY OF THE CLAIMED SUBJECT MATTER

A. Summary of the Invention

Applicant developed a lead-free solder containing tin (Sn), silver (Ag), copper (Cu) and nickel (Ni) that has a liquidus temperature of 240°C or lower and suppresses dissolving of

copper of circuit layers of printed wiring boards into molten solder in soldering processes (Specification: p. 1, lines 6-11 and p. 8, lines 5-6).

B. Independent Claim 1

Independent claim 1 is directed to a lead-free solder. The lead-free solder consists essentially of: 1.0 to 2.0 wt.% of Ag (Specification: p. 14, ln.10 – p. 15, ln.8, Table 2; p. 16, ln. 4 – p. 17, ln. 3; p. 17, lines 4-12; p. 20, ln. 13 – p. 21, ln. 5, Table 4; p. 37, lines 11-14, Figs. 1-5E and 9; p. 39, ln 19 – p. 40, ln. 2, Figs. 9 and 10; p. 40, lines 3-6, Fig. 11; p. 40, lines 9-13, Figs. 11 and 12); 0.4 to 0.9 wt.% of Cu (Specification: p. 16, ln. 4 – p. 17, ln. 3, Table 2; p. 17, lines 14-20, Table 3; p. 18, ln. 4 – p. 19, ln. 6; p. 20, ln. 5 – p. 21, ln 5; p. 37, lines 1-22; pp. 38-40; Figs. 1-5E, 10 and 12); 0.02 to 0.06 wt.% of Ni (p. 21, lines 6-20; p. 37, lines 1-22; p. 38, lines 17-21; p. 40, lines 3-15; Figs. 1-3E and 6-12); a balance of Sn (Specification: p. 12, lines 13-16, Table 1; Fig. 1.); wherein said solder has a liquidus temperature of 240 °C or lower (Specification: p. 21, lines 6-20; p. 30, ln. 8 – p. 31, ln. 3; p. 38, ln. 22 – p. 39, ln. 4; p. 40, lines 3-13; Figs. 6, 7, 11 and 12).

C. Dependent Claim 2

Claim 2 depends from independent claim 1 and recites wherein the content of Ni is in the range from 0.02 to 0.04 wt.% (Specification: p. 7, lines 22-23; p. 14, lines 1-9; p. 21, lines 18-20; p. 39, lines 1-4 and Fig. 2).

D. Dependent Claim 3

Claim 3 depends from independent claim 1 and recites wherein said solder having a copper dissolution rate of 0.20 μm/sec or less (Specification: p. 8, lines 1-4; Table 3; p. 20, lines 9-12 and Table 5; p. 29, lines 4-9; p. 30, lines 16-19 and Tables 11-15; p. 39, ln. 5 – p. 40, ln. 2 and Figs. 8-10).

E. Dependent Claim 5

Claim 5 depends from independent claim 1 and recites wherein said solder having a liquidus temperature of 230° C or lower (Specification: p. 8, lines 6-7; p. 21, lines 18-20; p.38, lines 19-21; p. 40, lines 13-15; Tables 11, 12 and Figure 6).

F. Dependent Claim 6

Claim 6 depends from independent claim 1 and recites wherein said solder has a viscosity of 2.5 cP or lower (Specification: p. 8, lines 9-10; p. 29, lines 10-22; p. 30 lines 20-22 and Tables 11-15).

G. Dependent Claim 8

Claim 8 depends from independent claim 1 and recites further containing 0.02 to 0.06 wt.% of Fe (Specification: p. 7, lines 23-24; p. 14, lines 1-9; p. 21, ln. 21 – p. 22, ln. 24; p. 37, ln. 23 – p. 38, ln. 6 and Figs. 4A-4E; p. 38, ln. 22 – p.39, ln. 1 and Fig. 7).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. Whether claims 1-3, 5 and 6 are properly rejected under 35 U.S.C. § 103 as unpatentable over JP 10286689, JP 10034376, US 6241942 and DE 19816671.

B. Whether claims 1-3, 5, 6 and 8 are properly rejected under 35 U.S.C. § 103 as unpatentable over JP 08132279.

VII. ARGUMENT

A. Claims 1-3, 5 and 6 are Patentable Over JP 10286689, JP 10034376, US 6241942 and DE 19816671

Claims 1-3, 5 and 6 stand rejected under 35 U.S.C. § 103 as being unpatentable over Japanese Patent Nos. JP10286689 (abstract), JP 10034376 (abstract), U.S. Patent No. 6,241,942 ("Murata") and German Patent No. DE 19816671 (abstract). In particular, the Examiner asserts that the cited prior art discloses alloys that are "essentially 'bracketing' the claimed compounds,"

and that "it would have been obvious to one of ordinary skill in the art to select any portion of range, including the claimed range, from the broader range disclosed in a prior art reference."

DE 19816671 (abstract) discloses a Sn-Sb based alloy containing 0 < Sb <= 3.5 wt%, 0-3.0 wt% Ag, 0 < Cu <= 1.0 wt% and a first and/or second additive. The first additive consists of 0 < Cu <= 1.0 wt% and/or 0 < Ni <= 1.0 wt%. The second additive consists of 0 < P <= 1.0 wt% and/or 0 < Ge <= 1.0 wt%. The reference further suggest an Sn based alloy containing 0 < Ag <= 4.0 wt%, and further containing 0 < Cu <= 2.0 wt% and/or 0 < Ni <= 1.0 wt%.

JP 10034376 (abstract) discloses an Sn based alloy containing Bi (0.1-10 wt%), Ag (0.1-5 wt%), Cu (0.05-2 wt%), Ni (0.0005-0.1 wt%), P (0.0005-0.1 wt%) and In (0.01-0.5 wt%).

U.S. Patent No. 6241942 ("*Murata*") discloses an Sn-Zn based alloy containing Zn (7-10 wt%), and further containing one or more of Ni (0.01-1 wt%), Ag (0.1-3.5 wt%) and Cu (0.1-3.0 wt%). In addition, the alloy optionally contains at least one of Bi (0.2-6 wt%), In (0.5-3%) and P (0.001-1 wt%). The reference further discloses an Sn-Zn based alloy containing Zn (2-10 wt%), Bi (10-30 wt%), Ag (0.05-2 wt%) and optionally P (0.001-1 wt%).

JP 10286689 (abstract) discloses an Sn-Sb based alloy containing Sb (2.5-3.5 wt%) and Ag (1.0-3.5%), and further containing Cu (<= 1.0 wt%) or Ni (<= 1.0 wt%).

1. Claim 1

None of the Examiner's cited references discloses, teaches or suggests a solder alloy "consisting essentially of: (a) 1.0 to 2.0 wt% of Ag; (b) 0.4 to 0.9 wt% of Cu; (c) 0.02 to 0.06 wt% of Ni; and (d) a balance of Sn; [with] a liquidus temperature of 240°C or lower," as set forth in claim 1. The cited references describe alloys that have distinctly different elemental compositions that teach away from the claimed composition.

The present application describes a lead-free, Sn-Ag-Cu-Ni solder alloy that has a liquidus temperature that is sufficiently low to avoid damage to a printed wiring board (PWB), suppresses dissolution of the copper circuit layer of the PWB, is difficult to oxidize, and has good flow and adherence (wettability). Different types of lead-free alloys have been developed to replace traditional Sn-Pb alloys, including Sn-Cu, Sn-Zn and Sn-Ag-Cu solders. The properties of these solder alloys have been modified with the addition of other elements, such as Bi, In and Ge. However, each type of solder alloy has significant disadvantages -- e.g., high melting point (Sn-Cu), susceptibility to oxidation (Sn-Zn) and dissolution of copper circuit layers (Sn-Ag-Cu). (See pp. 1-5.)

The inventors have discovered that Ni and Ag have a synergistic effect in an Sn-Ag-Cu-Ni solder alloy such that when Ni is present in an extremely narrow, critical range of 0.02-0.06 wt% and Ag is present in a range of 1-2 wt%, the combination of Ni and Ag suppresses copper dissolution and provides a sufficiently low liquidus temperature. The presence of Ni in the Sn-Ag-Cu-Ni alloy supresses copper dissolution. However, the liquidus temperature of the Sn-Ag-Cu-Ni alloy increases as the Ni content increases. In general, the rate of increase in liquidus temperature as a function of the Ni content is accelerated when the Ag content is raised. Surprisingly, when the Ag content is in the range of 1-2 wt%, the liquidus temperature does not increase, even if the Ni content is changed over a range of 0-0.06%. (See e.g., p. 21; Figures 6, 11; Ex. A, Document 1.) When the Ni content is less than 0.02 wt%, there is insufficient suppression of copper dissolution. When the Ni content is greater than 0.06 wt%, the liquidus temperature of the alloy is too high.

The inventors have also discovered that Cu and Ag also have a joint effect on the liquidus temperature of the Sn-Ag-Cu-Ni alloy. The presence of Cu in the alloy suppresses copper

dissolution and provides good wettability. When the Cu content is less than 0.4 wt%, there is insufficient suppression of copper dissolution. However, the liquidus temperature of the alloy generally increases as the Cu content increases. The relatively lowest liquidus temperature and good wettability is obtained when the Cu content is about 0.8 wt%. Surprisingly, when the Cu content is in a range of 0.4-0.9 wt%, the liquidus temperature remains approximately the same even when the Ag content varies over a range of about 1-2%. (See Ex. A, Document 3.)

Thus, the present invention may be called a "selection invention." The inventors have found that the constituents of the Sn-Ag-Cu-Ni alloy unexpectedly interact synergistically in the claimed ranges -- particularly when Ni is present in the narrow, critical range of 0.02-0.06 wt% -- to suppress copper dissolution, provide a low liquidus temperature and good wettability, while avoiding the oxidation problems of Sn-Zn alloys.

a. The Composition of the Prior Art Alloys is Materially Different from the Claimed Invention

Contrary to the Examiner's assertions, the claimed Sn-Ag-Cu-Ni solder alloy is neither disclosed nor obvious in view of the prior art. Claim 1 of the present application is directed to a solder alloy "consisting essentially of: (a) 1.0 to 2.0 wt% of Ag; (b) 0.4 to 0.9 wt% of Cu; (c) 0.02 to 0.06 wt% of Ni; and (d) a balance of Sn." The solder alloy further has "a liquidus temperature of 240°C or lower." The term "consisting essentially of" refers to a composition that "includes the listed ingredients and is open to unlisted ingredients ***that do not materially affect the basic and novel properties of the invention***." *PPG Indus. v. Guardian Indus. Corp.*, 156 F.3d 1351, 1354, 48 U.S.P.Q.2d 1351, 1353-54 (Fed. Cir. 1998).

The Examiner's cited references disclose alloys that have materially different chemistries from the present invention. DE 19816671 and JP 10286689 disclose Sn-Sb type alloys that are distinctly different than the Sn-Ag-Cu-Ni solder alloy of the present application. As described in

U.S. Patent No. 6,179,935,[1] Sb is a principal constituent of the alloy that is used to provide increased the strength, but which reduces processability and wettability. (See col. 2, lines 10-14.) JP 10286689 similarly discloses that Sb is required to increase the strength of the alloy, but reduces the wettability. (See ¶ 19.) DE 19816671 further teaches the addition of P and Ge to suppress oxidation of the alloy. (See U.S. Patent No. 6,179,935, col. 6, lines 58-60.)

JP 10034376 discloses an Sn based alloy containing Bi, P and In. Bi is used to improve the strength of the alloy and reduce the melting temperature. (See ¶ 7.) In addition, JP 10034376 teaches that Ni and P should both be present to improve the thermal resistance of the alloy. (See ¶ 8.)

Murata discloses an Sn-Zn based alloy, that may also contain Bi, In and P. The Zn content directly affects the liquidus temperature of the alloy. (See col. 5, lines 56-59.) The addition of Bi and In is also used to reduce the melting temperature of the alloy. (See. col. 6, lines 29-31.) The addition of P is used to reduce the susceptibility to oxidation of the Sn-Zn alloy. (See col. 6, lines 53-63.)

Thus, DE 19816671 (Sb, P, Ge), JP 10034376 (Bi, P, In), *Murata* (Zn, Bi, In, P) and JP 10286689 (Sb) all disclose distinctly different types of alloys containing additional constituents that materially affect the basic properties of the solder alloy of the present invention "consisting essentially of" Sn, Ag, Cu and Ni, as set forth in claim 1.

b. The Prior Art Fails to Teach or Suggest the Unexpected Synergistic Effects of Ag/Ni and Ag/Cu on Copper Dissolution and Liquidus Temperature in the Claimed Ranges

Contrary to the Examiner's assertions, it would not be obvious "to select any portion of range, including the claimed range, from the broader range disclosed in a prior art." None of the

[1] Both the Examiner's cited reference DE 19816671 and U.S. Patent No. 6,179,935 claim priority based on the same Japanese Patent Nos. 9097828, 9191391 and 9212969.

Examiner's cited references discloses, teaches or suggests the unexpected synergistic effects of Ag/Ni and Ag/Cu in an Sn-Ag-Cu-Ni solder alloy, particularly in the ranges of "1.0 to 2.0 wt% of Ag[,] 0.4 to 0.9 wt% of Cu[, and] 0.02 to 0.06 wt% of Ni," as set forth in claim 1.

DE 19816671 discloses an Sn-Sb based alloy containing 0-3.0 wt% Ag, that ***optionally*** contains 0 < Cu <= 1.0 wt% ***and/or*** 0 < Ni <= 1.0 wt%. Thus, DE 19816671 teaches alloys that lack one or both of Cu and Ni. DE 19816671 (abstract) also suggests an Sn based alloy containing 0 < Ag <= 4.0 wt%, and further containing 0 < Cu <= 2.0 wt% ***and/or*** 0 < Ni <= 1.0 wt%. However, the broad ranges of the Ag and Ni constituents do not appear to be supported by the disclosure of DE 19816671. Only Sn-Ag-Cu-Ni alloys containing 6.0-3.0 wt% Ag and 0.1-0.2 wt% Ni appear to be described. (See U.S. Patent No. 6,179,935, Table 3.) Thus, DE 19816671 fails to disclose and, indeed, teaches away from the solder alloy of the present invention having the claimed ranges of Sn, Ag, Cu and Ni.

Furthermore, DE 19816671 does not teach or suggest that Ni may be used to suppress copper dissolution. U.S. Patent No. 6,179,935 only states that Ni provides improved strength and resistance to thermal fatigue. (See col. 6, lines 46-50.) Thus, DE 19816671 fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu, and, therefore, fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni, particularly the extremely narrow, critical range of 0.02-0.06 wt% Ni.

JP 10034376 discloses an Sn based alloy containing Bi, Ag (0.1-5 wt%), Cu (0.05-2 wt%), Ni (0.0005-0.1 wt%), P and In. However, JP 10034376 does not teach or suggest that Ni may be used to suppress copper dissolution. JP 10034376 only states that Ni and Cu may be used to improve strength and resistance to thermal fatigue. (See ¶¶ 7, 8.) Accordingly, JP 10034376 fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu and, therefore,

fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni, particularly the extremely narrow, critical range of 0.02-0.06 wt% Ni.

Murata discloses an Sn-Zn based alloy containing Zn, and further containing ***one or more*** of Ni (0.01-1 wt%), Ag (0.1-3.5 wt%) and Cu (0.1-3.0 wt%). Thus, *Murata* teaches alloys that lack one or both of Cu and Ni. Furthermore, *Murata* does not teach or suggest that Ni may be used to suppress copper dissolution. *Murata* only states that Ni and Cu may be used to improve mechanical strength (See col. 5, lines 62-64; col. 6, lines 14-15) and that Cu also suppresses copper diffusion (col. 6, lines 18-21). Accordingly, *Murata* teaches away from the Sn-Ag-Cu-Ni alloy of the present invention and fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu. Therefore, *Murata* fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni, particularly the extremely narrow, critical range of 0.02-0.06 wt% Ni.

JP 10286689 discloses an Sn-Sb based alloy containing Sb and Ag, and further containing Cu (<= 1.0 wt%) ***or*** Ni (<= 1.0 wt%). Thus, JP 10286689 teaches alloys that contain either Cu or Ni, but not both. Furthermore, JP 10286689 does not teach or suggest that Ni may be used to suppress copper dissolution. JP 10286689 only states that Ni and and Cu improve strength, thermal resistance and wettability. (See abstract.) Accordingly, JP 10286689 teaches away from the Sn-Ag-Cu-Ni alloy of the present invention and fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu. Therefore, JP 10286689 fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni, particularly the extremely narrow, critical range of 0.02-0.06 wt% Ni.

c. The Prior Art Fails to Disclose the Claimed Sn-Ag-Cu-Ni Alloy Having a Liquidus Temperature of 240° C or Lower

None of the Examiner's cited references discloses, teaches or suggests an alloy "consisting essentially of" Sn-Ag-Cu-Ni that has a liquidus temperature of "240° C or lower,"

particularly in the ranges of "1.0 to 2.0 wt% of Ag[,] 0.4 to 0.9 wt% of Cu[, and] 0.02 to 0.06 wt% of Ni," as set forth in claim 1. Although the prior art discloses a variety of alloys having a liquidus temperature <= 240° C, none of the prior art alloys have the claimed composition.

The Examiner has previously asserted that the claimed liquidus temperature constitutes a material property that "would have [been] inherently possessed by the teaching of the [prior art]." (See e.g., Office Action dated February 26, 2004.) The Examiner has not maintained this argument in the pending Office Action, dated November 2, 2004. Furthermore, the claimed liquidus temperature is not an inherent property of Sn-Ag-Cu-Ni alloys, but a result of the synergistic effects of Ag/Ni and Ag/Cu discovered by the inventors when Ag, Cu and Ni are combined in the claimed ranges. As discussed above, the Examiner's cited prior art fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu, and, therefore, fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni giving rise to the claimed liquidus temperature.

2. Claim 2

Claim 2 depends from claim 1 and recites the further limitation of Ni content "in a range from 0.02 to 0.04 wt%," which is narrower than the limitation of "0.02 to 0.06 wt%" set forth in claim 1. Therefore, claim 2 is believed to be patentable over the Examiner's cited prior art for the same reasons as set forth above with respect to claim 1.

3. Claim 3

Claim 3 depends from claim 1 and, therefore, is believed to be patentable over the Examiner's cited prior art for the same reasons as set forth above with respect to claim 1.

In addition, Claim 3 recites the further limitation of "a copper dissolution rate of 0.20 μm/sec or less." None of the prior art cited by the Examiner teaches or suggests that Ni may be

used to suppress copper dissolution, nor does the prior art disclose any "copper dissolution rate." The Examiner argues that "the claimed copper dissolution ... reads on zero, thus cited references need not disclose such limitation." The Examiner fails to provide any support for the asserted "zero" copper dissolution rate, nor does the Examiner provide any basis for the conclusion that the prior art need not disclose a limitation of the claim. The absence of any disclosure of the copper dissolution rate is not the same as a "zero" dissolution rate. To the extent that the Examiner's "zero" dissolution rate is based on this assumption, it is improper. See e.g., *In re Zurko*, 258 F.3d 1379, 59 U.S.P.Q.2d 1693 (Fed. Cir. 2001) (deficiencies of references cannot be saved by appeals to "common sense" and "basic knowledge" without evidentiary support.).

4. Claim 5

Claim 5 depends from claim 1 and recites the further limitation of "a liquidus temperature of 230° C or lower," which is narrower than the limitation of "240° C" set forth in claim 1. Therefore, claim 5 is believed to be patentable over the Examiner's cited prior art for the same reasons as set forth above with respect to claim 1.

5. Claim 6

Claim 6 depends from claim 1 and, therefore, is believed to be patentable over the Examiner's cited prior art for the same reasons as set forth above with respect to claim 1.

In addition, claim 6 recites the further limitation of "a viscosity of 2.5 cP or lower." The Examiner does not assert that the claimed viscosity is disclosed by the prior art, but argues that the claimed solder viscosity is a "material property [that] would have been inherently possessed by solder materials of cited references." The claimed viscosity is not an inherent property of Sn-Ag-Cu-Ni alloys, but a result of the synergistic effects of Ag/Ni and Ag/Cu discovered by the inventors when Ag, Cu and Ni are combined in the claimed ranges. As discussed above, the

Examiner's cited prior art fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu, and, therefore, fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni giving rise to the claimed viscosity.

B. Claims 1-3, 5, 6 and 8 are Patentable Over JP 08132279

Claims 1-3, 5, 6 and 8 stand rejected under 35 U.S.C. § 103 as being unpatentable over Japanese Patent No. JP 08132279 (abstract, Example ¶ 12). In particular, the Examiner asserts that the cited prior art discloses alloys that are "essentially 'bracketing' the claimed compounds," and that "it would have been obvious to one of ordinary skill in the art to select any portion of range, including the claimed range, from the broader range disclosed in a prior art reference.

JP 08132279 (abstract, Example ¶ 12) discloses an Sn-Zn based alloy containing Zn (1-15 wt%) and optionally containing Cu (<= 3.0 wt%). Paragraph 12 of the reference describes specific examples of alloy compositions that contain: Zn (8.9 wt%); Zn (8.9 wt%), Cu (0.5 wt%); and Zn (8.9 wt%), Cu (0.5 wt%), Sb (0.3 wt%). Paragraph 8 of the reference appears to suggest that the alloy may also contain one or more of Ag, In, Sb, Ni, Fe and Bi at a concentration of less than 5 wt%.

1. Claim 1

Similarly to the prior art discussed above, JP 08132279 describes alloys that have distinctly different elemental compositions and teach away from the claimed composition. JP 08132279 fails to disclose, teach or suggest an alloy "consisting essentially of: (a) 1.0 to 2.0 wt% of Ag; (b) 0.4 to 0.9 wt% of Cu; (c) 0.02 to 0.06 wt% of Ni; and (d) a balance of Sn; [with] a liquidus temperature of 240°C or lower," as set forth in claim 1. JP 08132279 only discloses various Sn-Zn based alloys, including an Sn-Zn alloy containing 0.5 wt% Cu, that have a materially different chemistry from the Sn-Ag-Cu-Ni solder alloy of the present invention. As

described in the abstract of JP 08132279, Zn is used to lower the melting point ("m.p.") of the alloy. Thus, JP 08132279 discloses a distinctly different type of alloy containing additional constituents that materially affect the basic properties of the solder alloy of the present invention "consisting essentially of" Sn, Ag, Cu and Ni, as set forth in claim 1.

Furthermore, JP 08132279 does not disclose, teach or suggest the unexpected synergistic effects of Ag/Ni and Ag/Cu in an Sn-Ag-Cu-Ni solder alloy, particularly in the ranges of "1.0 to 2.0 wt% of Ag[,] 0.4 to 0.9 wt% of Cu[, and] 0.02 to 0.06 wt% of Ni," as set forth in claim 1. Thus, contrary to the Examiner's assertions, it would not be obvious "to select any portion of range, including the claimed range, from the broader range disclosed in a prior art." JP 08132279 suggests that the disclosed Sn-Zn alloys may ***optionally*** include one or more of Ag, In, Sb, Ni, Fe and Bi at a concentration of less than 5 wt%. Thus, JP 08132279 teaches alloys that lack both Ag and Ni. Furthermore, JP 08132279 does not teach or suggest that Ni may be used to suppress copper dissolution. JP 08132279 only states that Ag, Ni and Fe strengthen the alloy. (See ¶ 11.) Accordingly, JP 08132279 teaches away from the Sn-Ag-Cu-Ni solder alloy of the present invention and fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu. Therefore, JP 08132279 fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni, particularly the extremely narrow, critical range of 0.02-0.06 wt% Ni.

In addition, JP 08132279 does not disclose, teach or suggest a solder alloy "consisting essentially of" Sn-Ag-Cu-Ni having a liquidus temperature of "240° C or lower," particularly in the ranges of "1.0 to 2.0 wt% of Ag[,] 0.4 to 0.9 wt% of Cu[, and] 0.02 to 0.06 wt% of Ni," as set forth in claim 1. Although JP 08132279 discloses a variety of alloys that may have a liquidus temperature <= 240° C, none of the prior art alloys have the claimed composition. As discussed above, the claimed liquidus temperature is not an inherent property of Sn-Ag-Cu-Ni alloys, but is

a result of the synergistic effects of Ag/Ni and Ag/Cu discovered by the inventors when Ag, Cu and Ni are combined in the claimed ranges. JP 08132279 fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu, and, therefore, fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni giving rise to the claimed liquidus temperature.

2. Claim 2

Claim 2 depends from claim 1 and recites the further limitation of Ni content "in a range from 0.02 to 0.04 wt%," which is narrower than the limitation of "0.02 to 0.06 wt%" set forth in claim 1. Therefore, claim 2 is believed to be patentable over JP 08132279 for the same reasons as set forth above with respect to claim 1.

3. Claim 3

Claim 3 depends from claim 1 and, therefore, is believed to be patentable over JP 08132279 for the same reasons as set forth above with respect to claim 1.

In addition, Claim 3 recites the further limitation of "a copper dissolution rate of 0.20 μm/sec or less." JP 08132279 fails to teach or suggest that Ni may be used to suppress copper dissolution, nor does JP 08132279 disclose any "copper dissolution rate." The Examiner argues that "the claimed copper dissolution ... reads on zero, thus cited references need not disclose such limitation." The Examiner fails to provide any support for the asserted "zero" copper dissolution rate, nor does the Examiner provide any basis for the conclusion that the prior art need not disclose a limitation of the claim. The absence of any disclosure of the copper dissolution rate is not the same as a "zero" dissolution rate. To the extent that the Examiner's "zero" dissolution rate is based on this assumption, it is improper. See e.g., *In re Zurko*, 258 F.3d 1379, 59 U.S.P.Q.2d 1693 (Fed. Cir. 2001) (deficiencies of references cannot be saved by appeals to "common sense" and "basic knowledge" without evidentiary support.).

4. Claim 5

Claim 5 depends from claim 1 and recites the further limitation of "a liquidus temperature of 230° C or lower," which is narrower than the limitation of "240° C" set forth in claim 1. Therefore, claim 5 is believed to be patentable over JP 08132279 for the same reasons as set forth above with respect to claim 1.

5. Claim 6

Claim 6 depends from claim 1 and, therefore, is believed to be patentable over JP 08132279 for the same reasons as set forth above with respect to claim 1.

In addition, claim 6 recites the further limitation of "a viscosity of 2.5 cP or lower." The Examiner does not assert that the claimed viscosity is disclosed by the prior art, but argues that the claimed solder viscosity is a "material property [that] would have been inherently possessed by solder materials of cited references." The claimed viscosity is not an inherent property of Sn-Ag-Cu-Ni alloys, but a result of the synergistic effects of Ag/Ni and Ag/Cu discovered by the inventors when Ag, Cu and Ni are combined in the claimed ranges. JP 08132279 fails to teach or suggest the synergistic effects of Ag/Ni and Ag/Cu, and, therefore, fails to provide any motivation to select the claimed ranges of Ag, Cu and Ni giving rise to the claimed viscosity.

6. Claim 8

Claim 8 depends from claim 1 and, therefore, is believed to be patentable over JP 08132279 for the same reasons as set forth above with respect to claim 1.

In addition, claim 8 recites the further limitation of "0.02 to 0.06 wt% of Fe." An Fe content of greater than 0.02 wt%, but less than 0.1 wt% suppresses copper dissolution, but does not significantly affect the liquidus temperature of the Sn-Ag-Cu-Ni-Fe alloy. However, when the Fe content is greater than 0.06 wt%, the viscosity of the alloy becomes excessively high.

(See pp. 21-23.) Thus, the inventors have discovered that the presence of Fe in the extremely narrow, critical range of 0.02-0.06 wt% suppresses copper dissolution, without significantly affecting the wettability of the Sn-Ag-Cu-Ni-Fe alloy.

Contrary to the Examiner's assertions, it would not be obvious "to select any portion of range [of Fe content], including the claimed range, from the broader range disclosed in [JP 08132279]." JP 08132279 does not teach or suggest that Fe may be used to suppress copper dissolution without affecting liquidus temperature, nor does JP 08132279 teach or suggest that Fe has a negative effect on viscosity. Therefore, JP 08132279 fails to provide any motivation to select the claimed range Fe, particularly the extremely narrow, critical range of 0.02-0.06 wt% Fe.

The Examiner further argues that the critical range of 0.02-0.06 wt% Fe is not supported by the exhibits ("Documents 1-3") attached to applicant's Preliminary Amendment dated July 26, 2004 (Ex. A). However, "Documents 1-3" do not relate to alloys containing Fe. The relevant support for the critical range of 0.02-0.06 wt% Fe is shown in the "Additional Table" attached to the Preliminary Amendment, which shows that an Fe content of 0.02-0.1 wt% provides approximately a 2-3 fold reduction in copper dissolution over a similar alloy lacking Fe. Moreover, the rate of copper dissolution is highest when both Ni and Fe are absent.

VIII. CLAIMS APPENDIX

Pursuant to 37 C.F.R. §41.37 (c)(1)(viii), a copy of only the claims involved in the appeal should be included in this appendix. Accordingly, this appendix includes a copy of the pending claims as they currently stand. Cancelled claims and their identification numbers are not included in this appendix.

1. A lead-free solder consisting essentially of:

(a) 1.0 to 2.0 wt.% of Ag;

(b) 0.4 to 0.9 wt.% of Cu;

(c) 0.02 to 0.06 wt.% of Ni; and

(d) a balance of Sn;

wherein said solder has a liquidus temperature of 240°C or lower.

2. The solder according to claim 1, wherein the content of Ni is in a range from 0.02 to 0.04 wt.%.

3. The solder according to claim 1, wherein said solder having a copper dissolution rate of 0.20 μm/sec or less.

5. The solder according to claim 1, wherein said solder having a liquidus temperature of 230°C or lower.

6. The solder according to claim 1, wherein said solder has a viscosity of 2.5 cP or lower.

8. The solder according to claim 1, further containing 0.02 to 0.06 wt.% of Fe.

IX. EVIDENCE APPENDIX

Exhibit A Applicant's Preliminary Amendment dated July 26, 2004.[2]

---

[2] Exhibit A contains the following typographical errors:

(1) p. 19, line 20 should read, "even if the [Ag] <u>Ni</u> content is changed from 0 to [0.6] <u>0.06</u> wt<u>%</u>."

(2) Document 1, line 4 should read, "(Cu = [0.08] <u>0.8</u> wt%)".

X. RELATED PROCEEDINGS APPENDIX

A Notice of Appeal was filed on March 1, 2005 in connection with U.S. Patent Application No. 10/127,927, filed on April 23, 2002, which is a divisional of the present application. An Appeal Brief has not been filed and no decisions have been rendered by a court or the Board in connection with U.S. Patent Application No. 10/127,927 as of yet. There are no related interferences.

XI. CONCLUSION

In view of the foregoing, reversal of the rejections of claims 1-3, 5, 6 and 8 and allowance of claims 1-3, 5, 6 and 8 are respectfully requested.

Respectfully submitted,

Dated: May 2, 2005

Brian J. Lum, Reg. No. 54,282
MICHAEL BEST & FRIEDRICH LLP
401 North Michigan Avenue, Suite 1900
Chicago, Illinois 60611
Tel: (312) 222-0800
Fax: (312) 222.0818

Appl. No.	:	09/671,084
Confirmation No.	:	6569
Applicant	:	Toshihide Ito
Filed	:	September 27, 2000
Title	:	Sn-Ag-Cu Solder and Surface Treatment and Parts Mounting Methods Using the Same
TC/A.U.	:	1742
Examiner	:	Sikyin Ip
Docket No.	:	200335-0037

I, Elizabeth M. Campbell, hereby certify that this correspondence is being deposited with the U.S. Postal Service as first class mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date of my signature.

Elizabeth M. Campbell
Signature

7/26/2004
Date of Signature

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Sir:

In response to the Office action of February 26, 2004, please amend the above-identified application as follows:

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims which begins on page 11 of this paper.

Remarks begin on page 13 of this paper.

EXHIBIT

A

Amendments To The Specification:

Please amend the specification on paragraph 15, page 4, lines 17-24 of the application as follows:

[0015] Generally, it has been known that a phenomenon termed ~~"copper leaching"~~ "copper dissolution" occurs when a Sn--Ag--Cu alloy is coated on the plated Cu circuit layer of a PWB by the hot-air leveling method. The ~~"copper leaching"~~ "copper dissolution" is a phenomenon that Cu contained in the circuit layer dissolves in the molten alloy thus coated and as a result, the thickness of the circuit layer decreases. In the worst case, the circuit layer is broken or cut due to the ~~"copper leaching"~~ "copper dissolution" phenomenon. This degrades the reliability of the PWB.

Please amend the specification on paragraph 16, page 5, lines 1-6 of the application as follows:

[0016] It has also been known that the ~~"copper leaching"~~ "copper dissolution" occurs when a Sn--Ag--Cu alloy is used as a solder for mounting electronic parts or components onto the Cu circuit layer of a PWB by the flow-soldering method. In this case, soldering defects tend to occur due to the ~~"copper leaching"~~ "copper dissolution" thereby degrading the reliability of the PWB.

Please amend the specification on paragraph 17, page 5, lines 7-14of the application as follows:

[0017] Accordingly, to effectively prevent the ~~"copper leaching"~~ "copper dissolution" phenomenon, the Japanese Non-Examined Patent Publication No. 11-77368 published in Mar. 23, 1999, discloses a "Pb-free solder alloy" that contains a Sn--Pb--Bi--In alloy as its main ingredient and 1 to 4 wt % of Cu. The Japanese Non-Examined Patent Publication No. 9-94688 published in 1997 discloses a "Pb-free solder alloy" that contains a Sn--Zn--Ni alloy as its main ingredient and 0.1 to 3 wt % of Cu.

Please amend the specification on paragraph 18, page 5, lines 15-24 of the application as follows:

[0018] The solder alloys disclosed in the above-identified Publication Nos. 11-77368 and 9-94688 have an object to prevent the ~~"copper leaching"~~ "copper dissolution" phenomenon by addition of Cu. However, the solder alloy disclosed in the Publication No. 11-77368 has a disadvantage that the melting point is excessively high because its solidus and liquidus temperatures are 208° and 342°, respectively. The solder alloy disclosed in the Publication No. 9-94688 has a disadvantage that it is easily oxidized This is because the solder alloy is one of Sn--Zn alloys having the above-described easy oxidation property.

Please amend the specification on paragraph 19, page 6, lines 11-13 of the application as follows:

[0019] In addition, none of the above-described Publication Nos 2-34295, 2-179388, 4-333391, and 6-269983 refers to the ~~"copper leaching"~~ "copper dissolution" phenomenon. Similar to the above-described Publication Nos. 11-77368 and 9-94688, the above-described Publication No. 11-77366 discloses the fact that the ~~"copper leaching"~~ "copper dissolution" phenomenon can be suppressed by addition of Cu. However, the Publication No. 11-77366 does not describe how much the addition of Cu suppresses the same phenomenon.

Please amend the specification on paragraph 20, page 6 lines 11-13 of the application as follows:

[0020] Accordingly, an object of the present invention is to provide a Pb-free solder that has a satisfactory low melting point and that suppresses effectively the ~~"copper leaching"~~ "copper dissolution" phenomenon.

Please amend the specification on paragraph 31, page 7 lines 10-18 of the application as follows:

[0031] With the Pb-free solder according to the first aspect of the invention, the ~~"copper leaching"~~ "copper dissolution" phenomenon can be effectively suppressed due to existence of Ni and/or Fe within the specific amount range. Also, since the amount of the Ni and/or Fe is very small, the solder according to the first aspect of the invention has a composition similar to the eutectic composition of Sn--Ag--Cu solders without Ni and Fe. Thus, the solder has a low liquidus temperature (i.e., a low melting point).

Please amend the specification on paragraph 34, page 8 lines 1-4 of the application as follows:

[0034] Preferably, the solder according to the first aspect of the invention has a copper dissolution rate of 0.15 μm or less (or 0.20 μm or less). This is to ensure the suppression of the ~~"copper leaching"~~ "copper dissolution" phenomenon.

Please amend the specification on paragraph 58 page 11 lines 20-24 and page 12 line 1 of the application as follows:

[0058] To accomplish the above-described objects, the inventors conducted experiment and research vigorously and as a result, they found the fact that the ~~"copper leaching"~~ "copper dissolution" phenomenon can be effectively suppressed if proper amount of Ni and/or Fe is/are added to a Sn--Ag--Cu solder alloy. Through the fact thus found, they created the present invention.

Please amend the specification on paragraph 66, page 12, lines 13-18 of the application as follows:

[0066] FIG. 1 and the following Table 1 express the copper dissolution rate μm/sec) obtained under the condition that specific elements Ag, Cu, Bi, In, Zn, Fe, or Ni were added to Sn as its main ingredient. From FIG. 1 and Table 1, it is seen that the higher the copper dissolution rate is, the more easily the ~~"copper leaching"~~ "copper dissolution" phenomenon progresses.

Please amend the specification on paragraph 67, page 14, lines 1-9 of the application as follows:

[0067] As seen from FIG. 1 and Table 1, the copper dissolution rate is conspicuously decreased by addition of a trace of of Ni or Fe while the decrease in the copper dissolution rate is relatively small when other elements than Ni and Fe are added. Generally, the liquidus temperature decreases with the increasing amount of the added element or elements to an alloy with the eutectic composition. Thus, it can be said that the ~~"copper leaching"~~ "copper dissolution" phenomenon can be effectively suppressed by addition of Ni and/or Fe while the liquidus temperature is suppressed to rise.

Please amend the specification on paragraph 77, page 17, lines 14-15 of the application as follows:

[0077] Cu is an element having a function of suppressing the ~~"copper leaching"~~ "copper dissolution" phenomenon of the Cu circuit layers of the PWB.

Please amend the specification on paragraph __, page __, lines __ of the application as follows:

Please amend the specification on paragraph 79, page 18, lines 4-8 of the application as follows:

[0079] As seen from Table 3, the copper dissolution rate decreases with the increasing amount of Cu added, which means that the ~~"copper leaching"~~ "copper dissolution" phenomenon can be suppressed by addition of Cu. It is also found that the liquidus temperature rises as the amount of Cu is increased.

Please amend the specification on paragraph 80, page 18, lines 9-16 and page 19, lines 1-2 of the application as follows:

[0080] From the viewpoint of the tendency from Table 3, with the solder according to the invention, in which Ni and/or Fe is/are added to an Sn--Ag--Cu alloy, the effect to suppress the ~~"copper leaching"~~ "copper dissolution" phenomenon is insufficient when the Cu content is less than 0.4 wt %. On the other hand, when the Cu content is greater than 1.3 wt %, the liquidus temperature is excessively high, causing the possibility that defects tend to occur in the PWB and/or electronic components mounted thereon in the soldering process. Accordingly, it is preferred that the Cu content is in the range from 0.4 wt % to 1.3 wt %, the reason of which is explained later.

Please amend the specification on paragraph 87 page 21, lines 7-10 of the application as follows:

[0087] As described previously, Ni is an element having a function of suppressing the ~~"copper leaching"~~ "copper dissolution" phenomenon of the Cu circuit layers of the PWB. This function becomes distinctive by addition of a trace of Ni.

Please amend the specification on paragraph 88, page 21, lines 11-21 of the application as follows:

[0088] With the Sn--Ag--Cu alloy to which Ni is added according to the invention, when the Ni content is less than 0.02 wt %, the effect to suppress the ~~"copper leaching"~~ "copper dissolution" phenomenon is insufficient. On the other hand, when the Ni content is greater than 0.06 wt %, the liquidus temperature is excessively high, causing a danger that some defect occurs in the PWB and/or electronic components. As a result, the preferred content of Ni is 0.02 to 0.06 wt %, in which the liquidus temperature is set at 240° or lower. It is found that the more preferred content of Ni is 0.02 to 0.04 wt %, in which the liquidus temperature is set at 230° or lower.

Please amend the specification on paragraph 90, page 21, lines 22-23 and page 22, lines 1-2 of the application as follows:

[0090] As described previously, like Ni, Fe is an element having a function of suppressing the ~~"copper leaching"~~ "copper dissolution" phenomenon of the Cu circuit layers of the PWB. This function becomes distinctive by addition of a trace of Fe.

Please amend the specification on paragraph 91, page 22, lines 3-11 of the application as follows:

[0091] With the Sn--Ag--Cu alloy to which Fe is added according to the invention, when the Fe content is less than 0.02 wt %, the effect to suppress the ~~"copper leaching"~~ "copper dissolution" phenomenon is insufficient. On the other hand, the rise of the liquidus temperature due to the addition of Fe is relatively smaller than that caused by the addition of Ni. In particular, when the Fe content is less than 0.1 wt %, the liquidus temperature scarcely changes due to the addition of Fe. However, if the Fe content is greater than 0.06 or 0.05 wt %, the viscosity is excessively high, causing the following problems.

Please amend the specification on page 45, lines 1-14 of the application as follows:

ABSTRACT OF THE DISCLOSURE

A Pb-free solder is provided, which has a satisfactory low melting point and suppresses effectively the ~~"copper leaching"~~ "copper dissolution" phenomenon. The solder is difficult to be oxidized and has a high wettability. The solder consists essentially of (a) 1.0 to 4.0 wt % of Ag, (b) 0.4 to 1.3 wt % of Cu; (c) at least one of 0.02 to 0.06 wt % (or 0.02 to 0.04 wt %) of Ni and 0.02 to 0.06 wt % (or 0.02 to 0.05 wt %) of Fe; and (d) a balance of Sn. The solder has a copper dissolution rate of 0.20 or 0.15 μm or less. Preferably, the solder has a liquidus temperature of 240° or lower, in which a satisfactory low melting point is ensured. More preferably, the solder has a liquidus temperature of 230° or lower. It is preferred that the solder has a viscosity of 2.5 cP or lower.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently amended) A lead-free solder consisting essentially of:

(a) 1.0 to 2.0[[2.99]] wt.% of Ag;

(b) 0.4 to 0.9[[1.3]] wt.% of Cu;

(c) 0.02 to 0.06 wt.% of Ni; and

(d) a balance of Sn;

wherein said ~~Ni serves to lower the copper dissolution rate of said~~ solder has a liquidus temperature of 240°C or lower.

2. (Previously presented) The solder according to claim 1, wherein the content of Ni is in a range from 0.02 to 0.04 wt.%.

3. (Currently amended) The solder according to claim 1, wherein said solder having a copper dissolution rate of 0.20 μm/sec or less.

4. (Canceled)

5. (Previously presented) The solder according to claim 1, wherein said solder having a liquidus temperature of 230°C or lower.

6. (Previously presented) The solder according to claim 1, wherein said solder has a viscosity of 2.5 cP or lower.

7. (Canceled)

8. (Currently Amended) The solder according to claim 1, further containing 0.02 to 0.06[[0.05]]

wt.% of Fe.

Claims 9-24. (Canceled)

REMARKS

The above amendments are intended to place this case in condition for allowance over the principal reference cited to date, WO98/34755 as well as the U.S. Patent No. 6,231,691 which is cited in the Information Disclosure Statement accompanying this amendment.

The following points are additionally noted:

1) The upper limits on Ag of the 2.0 wt.% avoids overlap with the teaching of WO98/34755. This level of Ag helps lower the cost of the product and suppresses the increase in liquidus temperature caused by the addition of Ni.

2) The wording "copper leaching" has been changed to "copper dissolution" in the specification in order to apply language more commonly used for this phenomenon in the U.S. This is simply an improvement in translation and does not constitute new matter.

3) Obviousness rejections.

a) Earlier in the prosecution of this case, the Examiner argued that the then-claimed features of the invention were substantially disclosed in WO98/34755.

In the amended claims, the range of Ag has been narrowed from 1.0 to 2.0 wt.%. The range of Cu has been narrowed from 0.4 to 0.9 wt.% and the claims have been amended to require that the claimed solder have a liquidus temperature of 240°C or lower. Also, the reference to the presence of Fe has been deleted. As a result, it is believed that the claimed invention, particularly in terms of Ag and Cu percentages, is outside of the teaching of WO98/34755 and is neither anticipated nor rendered obvious by that reference.

b) In WO98/34755, a Sn-Ag-Cu eutectic solder is modified with Ni and/or Fe to enhance high temperature microstructural stability and thermal-mechanical fatigue strength without decreasing solderability. (See Abstract) WO98/34755 calls for the addition of Ag to a eutectic solder containing 4.7 wt.% of Ag and 1.7 wt.% of Cu, where Ag is set in a range from 3.5 to 7.7 wt.% or from 3 to 4 wt.%. No other disclosure is seen.

Moreover, in the second paragraph of page 8 of WO98/34755, a range of Ag of 3 wt.% or greater is explained. No disclosure nor teaching to a range of Ag of 2 wt.% or lower is seen.

c) Furthermore, in WO98/34755, a range of Ni of 1 wt.% or lower is disclosed. However, an extremely narrow range of 0.02 to 0.06 wt.% of Ni (and that of 0.02 to 0.06 wt.% of Fe) as shown in the amended claim 1 of the invention is not disclosed or taught.

Concerning the range of Cu, in the second paragraph of page 8 of WO98/34755, two concrete examples are disclosed. The first example contains 3.5 to 7.7 wt.% of Ag, 1 to 4 wt.% of Cu, and 1 wt.% or less of Ni. The second example contains 3 to 4 wt.% of Ag, 0.5 to 4 wt.% of Cu, and 1 wt.% or less of Ni.

d) The features of the solder of the invention as claimed in amended claim 1 are the selected ranges of Ag, Cu, and Ni, and the liquidus temperature of 240 °C or lower. WO98/34755 fails to disclose and teach the Ag and Cu ranges of the invention as claimed.

Moreover, the extremely narrow range of 0.02 to 0.06 wt.% of Ni (and that of 0.02 to 0.06 wt.% of Fe) as shown in the amended claim 1 of the invention is not disclosed nor taught in the reference WO98/34755. This range was presented by the present invention.

Therefore, the solder of the invention as claimed in the amended claim 1 is quite different from the solder disclosed in WO98/34755.

Taking the extremely narrow range of 0.02 to 0.06 wt.% of Ni (and that of 0.02 to 0.06 wt.% of Fe), the invention as claimed may be called as a "selection invention" which is neither taught nor suggested in WO98/34755.

e) The following explanation is intended to present additional grounds for establishing the patentability of the invention.

(i) From Tables 11 to 15 in the English specification of the present application and the Additional Table attached herewith, Documents 1 to 3 are derived as attached herewith.

In the Additional Table, sample Nos. 73 - 78 (Ag = 1 wt%) are shown in Table 9 of the present application, sample Nos. N 18 – N 34 (Ag = 2 wt%) were newly added based on the experiment carried out by the

inventors in the same way as shown in the English specification, and the sample Nos. N 35 - N38 were made by the inventors according to the concrete examples shown on page 11 of WO98/34755, and added based on the experiment carried out by the inventors in the same way as shown in the English specification.

Document 1 includes six graphs showing the relationship between the liquidus temperature (°C) and the Ni content (wt.%) of the Sn-Ag-Cu-Ni solder according to the invention, where the Ag content is set at 0.5, 1, 2, 3.5, 4, and 5 wt.% and the Cu content is fixed at 0.8 wt.%. Part of these relationships is shown in Fig. 6 of the present application.

The first graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 0.5 wt.% and Cu = 0.8 wt.%. This graph is easily derived from formed by the samples 62 to 67 in Table 9 and their corresponding points are arranged from right to left in the graph.

The second graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 1 wt.% and Cu = 0.8 wt.%. This graph is easily derived from samples 73 to 78 in Table 9 and their corresponding points are arranged from right to left in the graph.

The third graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 2 wt.% and Cu = 0.8 wt.%. This graph is easily derived from samples N18 to N23 in Additional Table and their corresponding points are arranged from right to left in the graph.

The fourth graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 3.5 wt.% and Cu = 0.8 wt.%. This graph is easily derived from samples 1 to 6 in Table 6 and their corresponding points are arranged from right to left in the graph.

The fifth graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 4 wt.% and Cu = 0.8

wt.%. This graph is easily derived from samples 84 to 89 and their corresponding points are arranged from right to left in the graph.

The sixth graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 5 wt.% and Cu = 0.8 wt.%. This graph is easily derived from samples 95 to 100 and their corresponding points are arranged from right to left in the graph.

(ii) Document 2 includes four graphs showing the relationship between the liquidus temperature (°C) and the Ni content (wt.%)of the Sn-Ag-Cu-Ni solder according to the invention, where the Cu content is set at 0.4, 0.8, 1.2, and 1.6 wt.% and the Ag content is fixed at 3.5 wt.%.

The first graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 3.5 wt.% and Cu = 0.4 wt.%. This graph is easily derived from samples 29 to 34 in Table 7 and their corresponding points are arranged from right to left in the graph.

The second graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 3.5 wt.% and Cu = 0.8 wt.%. This graph is easily derived from samples 1 to 6 in Table 6 and their corresponding points are arranged from right to left in the graph.

The third graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 3.5 wt.% and Cu = 1.2 wt.%. This graph is easily derived from samples 40 to 45 in Table 8 and their corresponding points are arranged from right to left in the graph.

The fourth graph shows the relationship between the liquidus temperature (°C) and the Ni content (wt.%) at Ag = 3.5 wt.% and Cu = 1.6 wt.%. This graph is easily derived from samples 51 to 56 in Table 8 and their corresponding points are arranged from right to left in the graph.

(iii) Document 3 includes two graphs showing the relationship between the liquidus temperature (°C) and the Cu content (wt.%)of the Sn-Ag-Cu solder according to the invention, where the Ag content is set at 1 and 2 wt.%.

The first graph shows the relationship between the liquidus temperature (°C) and the Cu content (wt.%) at Ag = 1 wt.% without Ni. This graph is easily derived from the data set on the third line in Table 4.

The second graph shows the relationship between the liquidus temperature (°C) and the Cu content (wt.%) at Ag = 2 wt.% without Ni. This graph is easily derived from the data set on the fourth line in Table 4.

(iv) As shown in Fig. 6 of the present application and as seen from the graphs of Document 1, the liquidus temperature of the Sn-Ag-Cu-Ni solder rises dependent on the increase of the Ni content. From the graphs in Document 1, it is seen that the rising rate of the liquidus temperature increases as the Ag content increases.

Compared with the case where Ag = 1 wt.% and the case where Ag = 2 wt.%, the liquidus temperature further rises by approximately 5 °C at Ni = 0.06 wt.% when Ag = 3.5 wt.%. If Ag = 4 wt.%, the liquidus temperature further rises by approximately 7 °C at Ni = 0.06 wt.%. If Ag = 5 wt.%, the liquidus temperature further rises by approximately 12 °C at Ni = 0.06 wt.%.

In this way, the rising effect of the liquidus temperature with addition of Ni is gradually enhanced according to the increase of the Ag content. This means that addition of Ni to a Sn-Ag-Cu solder induces a synergistic effect with Ag on the rise of the liquidus temperature.

Therefore, to suppress the liquidus temperature at 240 °C or lower of the Sn-Ag-Cu-Ni solder, as seen from the graphs of Document 1, it is necessary that the Ni content is 0.06 wt.% or less and that the Ag content is 4 wt.% or lower.

In particular, to suppress the liquidus temperature at 230 °C or lower (which is more preferred), as seen from the graphs of Document 1, it is necessary that the Ni content is 0.06 wt.% or less and that the Ag content is 3.5 wt.% or lower.

Moreover, where the Ag content is kept in the range from 1.0 to 2.0 wt.%, as shown in the amended claim 1, the rise of the liquidus

temperature is effectively suppressed even if the Ni content is 0.06 wt.%, i.e., the Ni content is at the maximum value in the range of 0.02 to 0.06 wt.%. (This is also seen from the graph in Fig. 11 of the present application.)

(v) WO98/34755 fails to disclose the fact that addition of Ni to a Sn-Ag-Cu solder induces a synergistic effect with Ag on the rise of the liquidus temperature. In other words, WO98/34755 fails to disclose and teach the fact that the rise of the liquidus temperature is excessive if the Ni content exceeds 0.06 wt.%.

Therefore, it cannot be fairly said that WO98/34755 discloses Sn-Ag-Cu-Ni solders whose liquidus temperature is 240 °C or lower. In other words, because the Sn-Ag-Cu-Ni solder disclosed in WO98/34755 contains a greater Ag content and a greater Ni content than those of the present invention, it seems not to have a liquidus temperature of 240 °C or lower.

(vi) As seen from the graphs of Document 2, the liquidus temperature of the Sn-Ag-Cu-Ni solder rises dependent on the increase of the Ni content. Moreover, it is seen that the rising rate of the liquidus temperature is approximately the same regardless of the Ni content.

Compared with the case where Cu = 0.8 wt.% and Ag = 3.5 wt.%, the liquidus temperature further rises by approximately 9 °C at Ni = 0.06 wt.% when Cu = 1.2 wt.%. When Cu = 1.6 wt.%, the liquidus temperature further rises by approximately 16 °C at Ni = 0.06 wt.%. In this way, to suppress the liquidus temperature at 240 °C or lower in the case where the Ni content is 0.06 wt.% or less and the Ag content is 3.5 wt.% or lower, as seen from the graphs of Document 2, it is seen that the Cu content needs to be 1.2 wt.% or lower.

(vii) WO98/34755 discloses solder including Ni exceeding 0.06 wt.% and Cu exceeding 1.2 wt.%. This solder has a liquidus temperature higher than 240 °C based on the teaching of the present invention.

Therefore, it cannot be fairly said that WO98/34755 discloses Sn-Ag-Cu-Ni solders whose liquidus temperature is 240 °C or lower. In other words, because the Sn-Ag-Cu-Ni solder disclosed in the reference WO98/34755 contains

a greater Cu content and a greater Ni content than those of the present invention, it seems not to have a liquidus temperature of 240 °C or lower.

(viii) One of the contributions of the present invention exists in (a) finding the conditions that affect the liquidus temperature of Sn-Ag-Cu-Ni solders and (b) determining the percentages of the ingredients thereof in order to suppress the liquidus temperature at 240 °C or lower. This is not disclosed and taught in WO98/34755.

(ix) In addition, the invention utilizes the good wettability obtainable at about 0.8 wt.% of Cu when Ag is 1 wt.% or greater. This is not disclosed and taught in WO98/34755 as well.

Based on these differences, the invention as claimed is not obvious over WO98/34755.

(x) To clearly distinguish the present invention from WO98/34755, the limitation that the liquidus temperature is 240 °C or lower was added to the rejected claim 1, in addition to the narrowing of the Ag and Cu contents. The solder composition of the invention as amended is therefore quite different from that of WO98/34755.

The upper limit of "2 wt.%" of the Ag range is derived from the graphs in Document 1. Where Ag is 2 wt.% or lower, the liquidus temperature is not raised even if the Ag content is changed from 0 to 0.6 wt. The basis of the lower limit of "1 wt.%" of the Ag range is clearly shown in the original English specification relating the wettability (see Page 14, lines 14-24 of the English specification).

The range of Cu was narrowed to about 0.4 to about 0.9 wt.% in the amended claim 1. This is to suppress the rise of the liquidus temperature, the reason of which is explained below.

As seen from the graphs of Document 3, the liquidus temperature of the Sn-Ag-Cu solder is relatively lowest where the Cu content is 0.8 wt.% (Ag = 1 or 2 wt.%). Moreover, it is seen that the liquidus temperature is approximately the same where the Cu content is 0.4 and 0.9 wt.%, even if the Ag content is changed from 1 to 2 wt.%. This is the reason why the Cu content is limited to the range from about 0.4 and about 0.9 wt.%.

It is respectfully requested that the objections and rejections in the pending office action be withdrawn in view of the amendments and arguments presented above. If, in the opinion of the Examiner, a telephone conference would expedite the prosecution of the subject application, the Examiner is invited to call the undersigned attorney.

Respectfully submitted,

Date: 7/26/04

Barry W. Sufrin, Reg. No. 27,198
Michael Best & Friedrich LLP
401 North Michigan Avenue
Suite 1900
Chicago, Illinois 60611
(312) 222-0800

Docket No.: 200335-0037

S:\client\200335\0037\C0399239.1

ADDITIONAL TABLE

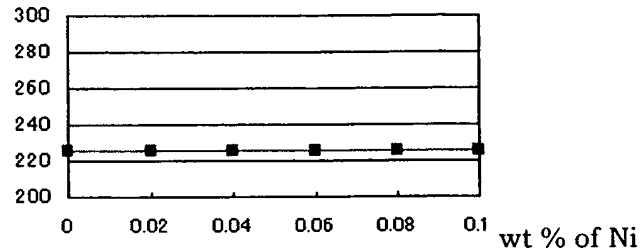
№	Sn	Ag	Cu	Ni	Fe	SOLIDUS TEMP.□□ □	LIQUIDUS TEMP.□□□	COPPER DISSOLUTION RATE □µm/sec□	VISCOSITY □□□□	SPREADING RATE □□□	REMARKS
73	98.2	1	0.8	0	0	217	225	0.2	1.7	77	1%Ag (SAMPLES 74-78)
74	98.18	1	0.8	0.02	0	217	225	0.13	1.7	76.8	
75	98.16	1	0.8	0.04	0	217	225	0.09	1.7	77.1	
76	98.14	1	0.8	0.06	0	217	225	0.06	1.7	77.3	
77	98.12	1	0.8	0.08	0	217	225	0.04	1.7	78.1	
78	98.1	1	0.8	0.1	0	217	235	0.03	1.8	77.8	
N18	97.2	2	0.8	0	0	217	225	0.144	2.1	73	2%Ag (ADDED FROM EXPERIMENT)
N19	97.18	2	0.8	0.02	0	217	225	0.114	2	72	
N20	97.16	2	0.8	0.04	0	217	225	0.095	1.9	74	
N21	97.14	2	0.8	0.06	0	217	225	0.072	1.9	75	
N22	97.12	2	0.8	0.08	0	217	226	0.033	1.9	71	
N23	97.1	2	0.8	0.1	0	217	226	0.03	1.9	76	
N29	97.16	2	0.8	0.02	0.02	217	225	0.054	1.8	73	
N30	97.14	2	0.8	0.04	0.02	217	225	0.049	1.8	76	
N31	97.13	2	0.8	0.05	0.02	217	225	0.037	1.9	75	
N32	97.12	2	0.8	0.06	0.02	217	225	0.033	2	75	
N33	97.1	2	0.8	0.08	0.02	217	225	0.021	2.1	75	
N34	97.08	2	0.8	0.1	0.02	217	225	0.02	2	75	
N35	93.3	4.7	1.7	0.3		217	265	0.021	3.5	71	WO9834755
N36	93.45	4.7	1.7	0.15		217	245	0.015	3.4	70	
N37	93.3	4.7	1.7		0.3	217	245	0.042	3.1	72	
N38	95.1	3.6	1	0.3		217	263	0.072	3.5	75	

□DOCUMENT 1□

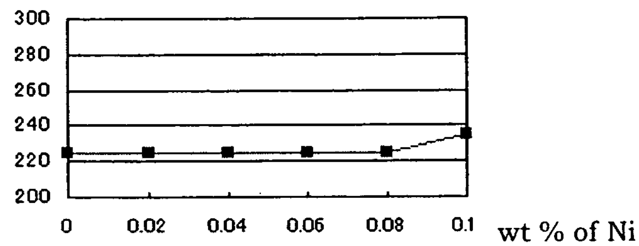
Liquidus Temperature change of Sn-Ag-Cu-Ni solder according to the Invention

(Cu = 0.08 wt%)

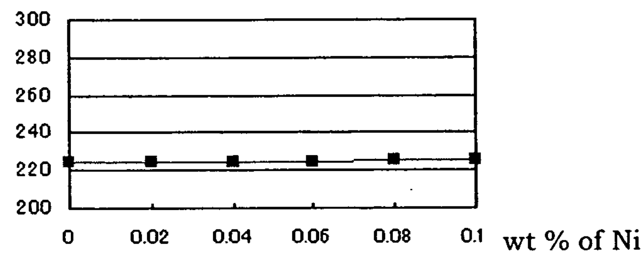
0.5 wt % of Ag Liquidus Temp. (Samples 62-67)



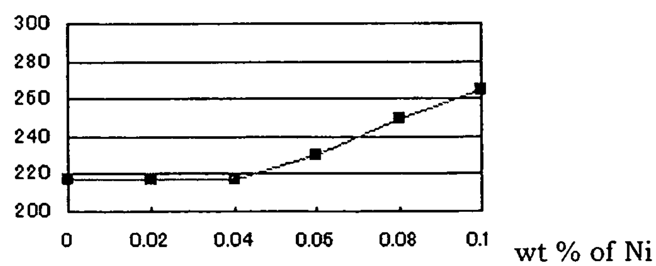
1 wt % of Ag Liquidus Temp. (Samples 73-78)



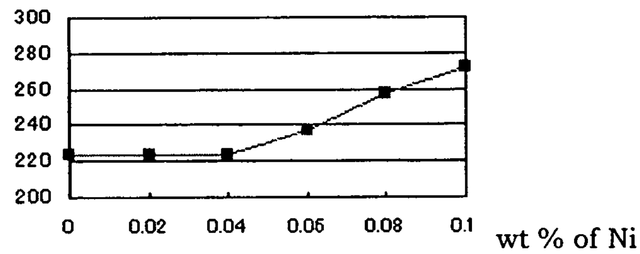
2 wt % of Ag Liquidus Temp. (Samples N18-N23)



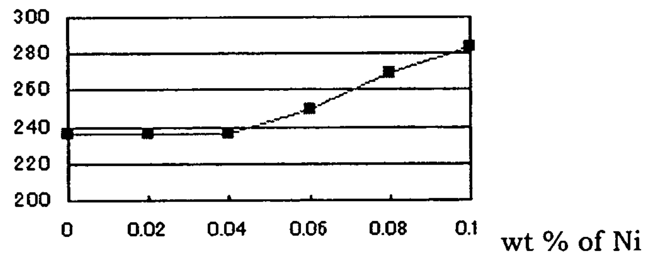
3.5 wt % of Ag Liquidus Temp. (Samples 1-6)



4 wt % of Ag Liquidus Temp. (Samples 84-89)



5 wt % of Ag Liquidus Temp. (Samples 95-100)



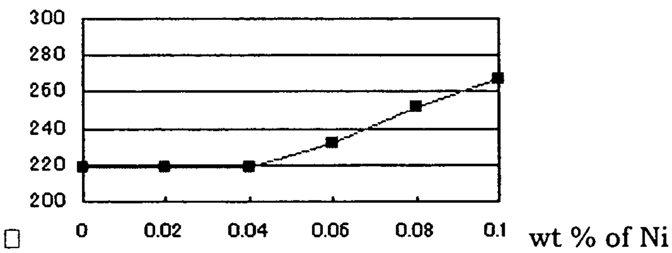
□DOCUMENT 2□

Liquidus Temperature change of Sn-Ag-Cu-Ni solder according to the Invention

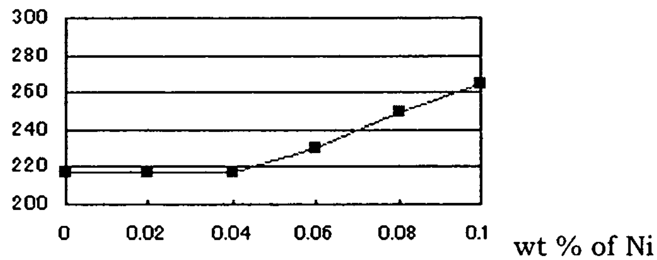
(Ag = 3.5 wt%)

0.4 wt % of Cu Liquidus Temp. (Samples 29-34)

□□□□□□□□

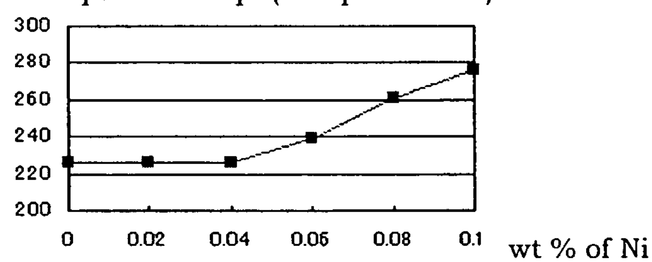


0.8 wt % of Cu Liquidus Temp. (Samples 1-6)



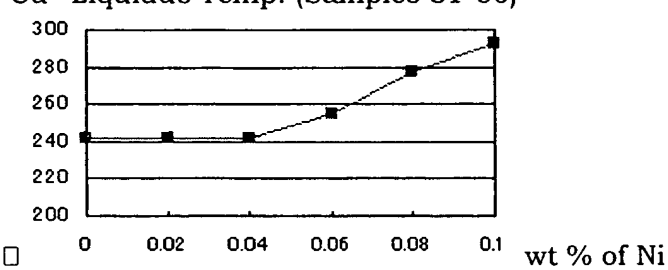
1.2 wt % of Cu Liquidus Temp. (Samples 40-45)

□□□□□□□□



1.6 wt % of Cu Liquidus Temp. (Samples 51-56)

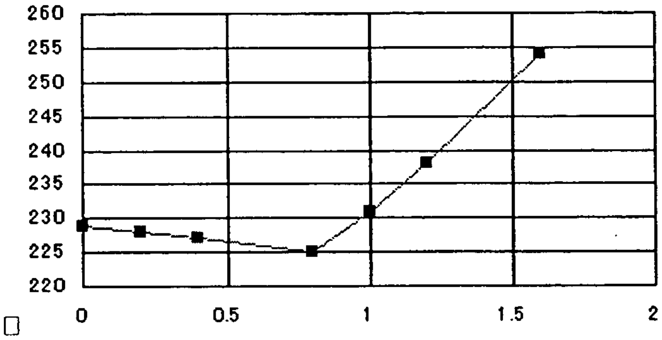
□□□□□□□□



□DOCUMENT 3□

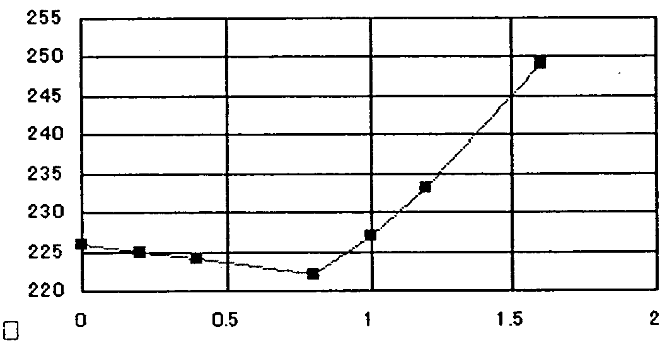
Liquidus Temperature change of Sn-Ag-Cu solder

1 wt % of Ag   Liquidus Temp. (Data from third line in Table 4)



□□□□□□□□ wt % of Cu

2 wt % of Ag   Liquidus Temp. (Data from fourth line in Table 4)



□□□□□□□□ wt % of Cu